Complex Bundles of Wires: the Influence of Wires' Meandering on Coupling Mechanisms

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Motivations

Bundles of wires constitute a widespread kind of interconnects in several industrial sectors. Deviation from ideality of such interconnections may cause severe integrity problems to transmitted signals. In this work the influence of wires' meandering onto crosstalk is investigated and an explanation of the macroscopic physical coupling mechanisms is proposed.

Coupling mechanisms

Currently an analytical model for non-uniform bundles of wires is not available and the prediction of crosstalk on complex real cables has to be carried out numerically [1]. This means that the number of simulations that a designer has to carry out in order to gain insight into the influence of parameters (loads, cable characteristics, cable structure, etc) onto crosstalk is extremely high. Such influence can be qualitatively predicted by means of a better understanding of the macroscopic coupling mechanisms. To this end, a n-wire non-uniform transmission line can be thought as the result of a construction process starting from a two-wire uniform line. These two wires are the ones between which the crosstalk is measured. The construction of the bundle involves two steps: 1) the perturbation of the distance between the two original parallel wires (so that the line is forced to be non-uniform) and 2) the adding up of other wires, at random position in the cross sections. The first alteration of the original two-wire uniform line causes the increase of crosstalk because of the non-linear dependence of crosstalk on wire distance. The second one basically produces a shielding effect that is negligible only for inductive coupling. The two effects above are additive in dB and therefore the coupling of a non-uniform bundle of wires is predictable adding them to the crosstalk predicted for a two-wire uniform line. The inductive coupling is nearly unaffected by wires' meandering, because the shielding of wires not directly involved in the coupling is negligible and the sole influence is due to wire distance between which the crosstalk is measured. On the contrary, the capacitive coupling is influenced by wires' meandering and by the shielding of wires not directly involved in crosstalk. The variance of crosstalk has a maximum for intermediate intricate bundles and minima for nearly uniform lines (as obviously expected), and for very intricate bundles. In this last case the two wires between which the crosstalk is measured are seldom adjacent or far away all along the line and therefore the crosstalk tends to assume only intermediate values.

Reference

[1] S. Salio, F. Canavero, J. Lefèbvre, and W. Tabbara, "Statistical description of signal propagation on random bundles of wires", *Proceedings of the 1999 Zurich Symp. on EMC.*